Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C.   20554

In the Matters of	)	
	)	
Rule Making to Amend Part 1 and Part 21	)	CC Docket No. 92-297
of the Commission's Rules to Redesignate	)	
the 27.5 - 29.5 GHz Frequency Band and	)	RM-7872; RM-7722
to Establish Rules and Policies for	)	
Local Multipoint Distribution Service;	)	
	)	
Applications for Waiver of the	)	
Commission's Common Carrier Point-to-	)	
Point Microwave Radio Service Rules;	)	
	)	
Suite 12 Group Petition for Pioneer's	)	PP-22
Preference;	)	
	)	
University of Texas - Pan	)	
American Petition for Reconsideration	)	
of Pioneer's Preference Request Denial	)	

MOTION OF MOTOROLA SATELLITE COMMUNICATIONS, INC. FOR LEAVE TO FILE SUPPLEMENTAL COMMENTS

Motorola Satellite Communications, Inc. ("Motorola")

hereby moves for leave to file the attached Supplemental

Comments (and accompanying Technical Appendix) in response to the

Notice of Proposed Rule Making and Tentative Decision in the

above-captioned proceedings.   The new data submitted by Suite 12

Group ("Suite 12") in its Reply Comments in this proceeding have

enabled Motorola to conduct additional and more rigorous analysis

regarding the feasibility of frequency sharing between the

proposed Local Multipoint Distribution Service ("LMDS") and the

feeder uplinks of Motorola's IRIDIUM™ system.   As set forth in the

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accompanying Supplemental Comments, LMDS systems would cause substantial harmful interference to the IRIDIUM™ system's satellite receivers; even more than had been apparent from the Suite 12 data previously known to Motorola.

Accordingly, Motorola respectfully asks the Commission for leave to file the attached Supplemental Comments setting forth its revised interference analysis. This submission will allow the Commission to obtain the benefit of Motorola's latest calculations based upon the previously unreleased data, and to assess fully the serious interference implications of frequency sharing between LMDS systems and IRIDIUM™ system feeder uplinks.

Respectfully submitted,

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Its Attorneys

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SUPPLEMENTAL COMMENTS OF
MOTOROLA SATELLITE COMMUNICATIONS, INC.

In its Comments and Reply Comments in the above-
captioned proceedings, Motorola Satellite Communications, Inc.
("Motorola") showed that, because of serious interference
problems, the proposed Local Multipoint Distribution Service
("LMDS") cannot co-exist in the same frequency bands with the
feeder uplinks of Motorola's IRIDIUM™ system which will use the
29.1-29.3 GHz band pursuant to the current co-primary Fixed-
Satellite Service ("FSS") allocation. Specifically, Motorola
demonstrated that the IRIDIUM™ system feeder uplinks would cause
harmful interference to both the two-way links and the video links

of LMDS systems, and that LMDS transmitters would similarly cause harmful interference to IRIDIUM™ system satellite receivers.

Motorola's interference analysis was based, in part, on data supplied by Suite 12 Group ("Suite 12"), the chief proponent of LMDS, in the "Sarnoff Report" attached to Suite 12's Petition for Rule Making. In its Reply Comments and appendices thereto, Suite 12 submitted additional data allowing a better definition of LMDS system parameters for its planned service. Use of this new information in Motorola's refined interference analysis leads to the conclusion that the interference caused by LMDS systems to an IRIDIUM™ system satellite receiver would be far greater than initially calculated in Motorola's earlier submissions in these proceedings.

Specifically, in its initial interference calculations Motorola assumed that each LMDS hub would have a radius of 6 miles and a coverage area of 113 square miles. Suite 12's subsequent submission, however, has enabled Motorola to determine that the radius of each LMDS hub would be only 3.9 miles, with its coverage area reduced to 47.8 square miles. Also, Suite 12 submitted a much higher antenna gain; 11-14 dB versus the 8 dB assumed by Motorola in its earlier filing.

Moreover, Motorola conducted a more rigorous analysis of the degree of interference from LMDS systems into the IRIDIUM™ system satellite recievers. This new analysis evaluates the interference contribution from every LMDS hub which may be located in the main beam of the satellite. These contributions were

-2-

calculated on the normalized basis of an equivalent baseline LMDS
hub located near the gateway. The analysis revealed that over
7,550 hubs would contribute to the mainbeam of the satellite at 10
degrees elevation at the gateway. These hubs accumulated to over
3,000 equivalent baseline hubs. The analysis also demonstrated
that significant interference starts at 170 equivalent baseline
hubs.

The net effect of these changes and new analysis is a
substantial upward adjustment in the amount of interference caused
by LMDS transmitters to IRIDIUM™ system satellite receivers.
These revisions are very significant. Contrary to the claims of
Suite 12, interference to IRIDIUM™ satellite receivers from LMDS
hubs cannot be avoided by relocating the IRIDIUM™ system earth
stations away from urban areas. The cumulative effect of
interference from LMDS hubs would cause unacceptable levels of
interference into IRIDIUM™ system satellite receivers irrespective
of the location of the feeder link gateways. Moreover, the
requisite coordination would be extremely difficult, if not
impossible, to achieve owing to the nature of LMDS. LMDS hub
antennas have a 360° omni-directional pattern in the horizontal
plane with each hub proposing to use the entire band.

Accordingly, Motorola maintains that a Fixed-Satellite Service set-aside is needed in at least the 29.1-29.3 GHz band in order to protect adequately the IRIDIUM™ system from harmful interference caused by proposed LMDS systems.

Respectfully submitted,

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Dated: November 22, 1993

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TECHNICAL APPENDIX

UPLINK INTERFERENCE FROM LMDS SYSTEMS
INTO A LEO SATELLITE
IN THE 30 GHZ FSS BAND

	Organization:
	Satcom Division, Chandler AZ
November 19, 1993	Motorola GSTG

1.0 Introduction & Summary

The FCC has proposed to amend Part 1 and Part 21 of the Commissions Rules to re-designate the 27.5 - 29.5 GHz band to include "Local Multipoint Distribution Service" (LMDS). One proposed LMDS system consists of a cellular like grid of hub transmitting stations broadcasting uniformly in the azimuth plane and with a moderate directivity in the vertical plane. These broadcasts would be FM video channels spaced every 20 MHz and would be received by individual subscriber units with high directivity antennas pointing towards the closest hub.

The question examined in this paper is whether LEO satellites using the 20/30 GHz bands for feeder links operating in the FSS band would suffer harmful interference to their uplink from a large number of hubs operating in major metropolitan areas. Motorola's Iridium™ system will be used as the reference LEO system as it already has filed for use of frequencies within the 29 GHz band requested by the LMDS proponents. Suite 12's technical characteristics will be employed for the LMDS system as its system characteristics are best detailed.

Motorola's initial comments pointed out that the LEO gateway stations would interfere with the narrow band data links between the LMDS subscribers and the hub terminal due to the 360° azimuth coverage of the hub antennas. The gateway uplink antenna would be continually tracking LEO satellites in all azimuth directions from each gateway site and at low elevation angles so that statistically a high number of interference events would occur between a gateway and hub. Reply comments by the LMDS proponents agreed and proposed that the gateway should be located over the radio horizon away from all urban areas that LMDS operators desire to service.

The effect of interference from LDMS stations into the LEO satellite remains undetermined. The question is, "Will a collection of hub transmitters generate sufficient signal levels at the input to a LEO satellite uplink such that the LEO operation will be affected?" In subsequent sections, this question is examined by taking the published characteristics of the Suite 12 system and the LEO parameters of the Iridium™ system.

In Section 2.0, a baseline interference power spectral density toward the LEO satellite from a single LMDS transmitter co-located with a LEO gateway is determined. Also evaluated is the power spectral density level from the LEO gateway.

In Section 3 the interference coupling is examined by establishing a relative interference factor for every LMDS station received by the main lobe of the LEO satellite. Antenna side lobes are ignored for simplicity. The relative interference factor is the product of the square of the range ratio of the range of the LMDS station to the LEO satellite to the range of the gateway to the satellite, the relative LMDS antenna gain from baseline gain, and the relative gain of the satellite antenna towards the LMDS station.

In Section 4.0 it is determined that harmful interference occurs if LMDS stations exist at more than 5.7 percent of the possible locations.

2.0 Uplink Interference Level

2.1 Transmitter Spectral Density Output per LMDS Hub

Suite 12 proposes to put 49 channels within a 1000 MHz band, spaced at 20 MHz intervals with an occupied bandwidth of 18 MHz for each channel to allow for guard bands between channels and narrow band reverse links. A single TWTA with 100 watts output capability will be backed off 7 dB to reduce IM distortion. The spectral power density of a wide band FM NTSC signal, without energy dispersion, can be approximated with a Gaussian shape in the frequency domain (CCIR Report 388-6).

The Motorola satellite feeder links occupy 4.75 MHz per channel. If one of Motorola's feeder link channels fell near a LMDS channel center frequency, then a peaking factor of at least 3 dB would be required to correct the LMDS PSD for the increased spectral density at the band center.

The transmitter spectral power density into the LMDS antenna can now be calculated as shown in Table 1.

Table 1 LMDS Transmitter Output Power Spectral Density	
PARAMETER	**VALUE**
TWTA Output Power Capability	20 dBW
TWTA Backoff	-7 dBW
49 Channels	-16.9 dB
Occupied BW per channel	-72.5 dB-Hz
FM Peaking Factor	3 dB
Xmtr Output PSD to the Antenna.	-73.4 dBW/Hz

2.2 Effective Radiated EIRP PSD

To provide a common basis, both systems must be normalized to a common term. This common basis was selected to be power spectral density (PSD - dBW/Hz) radiated toward the LEO satellite..

First, the LMDS System was evaluated for a baseline hub. Every hub in the service area will radiate power into a point in space on each of its channels with a magnitude proportional to the hub's antenna gain along the vector to that point.

The LMDS proponents suggest their antennas would have 10-13 dB gain with a uniform pattern in the azimuth direction. This means the gain must come entirely from the size of the vertical aperture and the directivity can be estimated to be 11-14 dB for a millimeter antenna suitable for this type of coverage (such as a bi-conical horn with a typical efficiency of 80%). These directivities translate to half power beamwidths of 57° to 40° [1]. It can therefore be safely assumed that each hub antenna has a nominal 3 dB beamwidth of ±25° relative to the horizontal plane. The shape of the antenna pattern in the vertical plane is estimated to be equal to Cos^2 (1.8 ø). Note: Cos^2 (1.8 *25°) = 0.5.

Table 2 LMDS HUB Uplink EIRP PSD	
PARAMETER	**VALUE**
Single Xmtr Output (Table 1)	-73.4 dBW/Hz
Antenna Feed Losses	-1 dB
Hub Antenna Gain - (11 dB * Cos^2 (1.8 *10°))	10.5 dB
Baseline Hub LMDS EIRP PSD	-63.9 dBW/Hz

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[1]   See Reply Comments of Suite 12 Group dated April 15, 1993 listing a hub main beamwidth of 25° above the horizon, this is consistent with their published gain of 10 dB which yields a half power beam width of 50°.

Second, the LEO gateway EIRP PSD was calculated as shown in Table 3 .

Table 3 LEO GATEWAY Uplink EIRP PSD	
PARAMETER .	VALUE
LEO EIRP	43.2 dBW
LEO Occupied Bandwidth	66.4 dBW (4.38 MHz)
LEO Output EIRP PSD	-23.2 dBW/Hz

2.3 Received Signal Power Spectral Densities

The relative levels between the systems at the LEO satellite receiver must be determined because of additional parameters in the link such as polarization.

Each gateway feeder link station has at least two tracking antennas for connecting PSTN traffic with the satellite constellation. To prevent service interruptions a make-before-break connection is made to each subsequent satellite. That is, the next satellite will be acquired before disconnecting from the present satellite. This means traffic links will have to be established at low elevation angles. The minimum angle is 10° at continental US latitudes where the separation between orbital planes is less. When the satellite position requires 10° elevation of the antenna at the gateway, the distance from the gateway to the LEO satellite is 2326 km.

CCIR Report No. 719-2 shows that a clear sky atmospheric attenuation at 29 GHz is 1.5 dB at low elevation angles.

Since the hub antennas are linearly polarized, and the satellite has a circular polarized main beam, then a 3 dB polarization loss in the LMDS link would also be expected.

There are four uplink/downlink horn antennas on each LEO spacecraft. Each antenna has a nominal 3 dB beamwidth of 5° at 29 GHz. The antenna has a peak gain of 30.1 dB.

Appendix A

INTERFERENCE EVALUATION

A.1   Introduction

The evaluation of interference to the LEO system from a LMDS system is based
on the concept of "baseline LMDS stations". A baseline LMDS station is a single
LMDS station co-located with the LEO gateway. Then a grid of LMDS stations is
evaluated by normalizing the effect of these stations to the baseline station.

The evaluation begins by establishing the location of all the LMDS stations
which are located in the mainbeam of the LEO satellite. This beam is pointed at the
LEO gateway.

The first assumption is that the worst case interference occurs when the LEO
satellite is at 10 degrees elevation from the LEO gateway. There is a possibility that
other elevation angles may produce greater interference, however, the 10 degree
elevation evaluation produced results so severe that co-frequency operation with
LMDS is impossible.

A.2   Coordinate system

A XY plane (see Figure A1) is placed tangent to the Earth at the LEO gateway
site. The origin of the coordinate system is the gateway site. The Y-axis lies directly
below the line from the LEO gateway to the LEO satellite. The satellite is located
above the -Y axis.

The uplink received power spectral densities from a baseline LDMS station and a LEO gateway can now be calculated as shown in Table 4.

TABLE 4 - RECEIVED PSD		
PARAMETER	LMDS VALUE	LEO VALUE
Uplink PSD EIRP	-63.9 dBW/Hz	-23.2 dBW/Hz
	(Table 2)	(Table 3)
Path Loss (2326 km)	-189.1 dB	-189.1 dB
Atmospheric Loss	-1.5 dB	-1.5 dB
Polarization Loss	-3 dB	0 dB
Satellite Ant Gain	30.1 dB	30.1 dB
LEO Received PSD	Iob = -227.4 dBW/HZ	Co = -183.7 dBW/Hz

3.0 Interference Analysis

3.1 Interference Criteria

To avoid harmful interference, the following relationship must be true:

Co/Io - PR > 0 dB.

Where:

Co   is the received signal level from the LEO gateway on a per Hz basis,

Io   is the received interference level from the accumulation of LMDS stations on a per Hz basis, and

Pr   is the LEO design minimum contribution from a single system.

Io is the summation of all the interference contributions received by the satellite. Therefore, Io equals the interference contribution from a baseline station (Iob) multiplied by the number of equivalent baseline stations (N). The above equation becomes:

Co + Pr - (Iob + N) > 0 dB

Since the LEO system design is based on a protection ratio of 16 dB for all sources, the protection ratio for LMDS alone should be 19 dB (half of the total Interference).

3.2 LMDS Interference into LEOs

Suite 12 indicates that a typical hub would serve a 47.8 square mile area or 122 sq. km (a square 11 km on a side).

This large number of high powered EIRP hub transmitters within the satellite uplink beam will linearly add at the input terminals of the satellite receiver[2] A rigorous calculation of the receive power requires an integration of each hub power, its gain in the direction of the satellite, slant range to satellite, and the pattern of satellite receive antenna.

The satellite will see an interference area as pictured in Figure 1 when the satellite position requires a gateway to be operating at a 10° elevation angle.

The analysis described in Appendix A was performed. The resultant sum of all the possible contributors exceeded 3000 baseline stations from the mainbeam area alone. When this is entered into the above equation, the result is:

$$(Co + Pr) - Io = -12.5 \, dB$$

Therefore, to achieve a tolerable interference level, the number of baseline stations must be limited. The maximum number of baseline LMDS stations which may be tolerated is:

$$Co - Pr - (Iob + N) > 0 \, dB \text{ or}$$

$$(-183.4) - (19) - (-224.7 + N) > 0 \, dB \text{ and}$$

$$N < 22.3 \, dB \text{ or } 170 \text{ LMDS baseline stations}$$

There is a possibility of approximately 3000 (or 34.8 dB) effective baseline stations (as though they were all near the gateway). This reduces the maximum probability that a transmitter site may be occupied to 5.7%, provided that they are evenly distributed throughout the footprint.

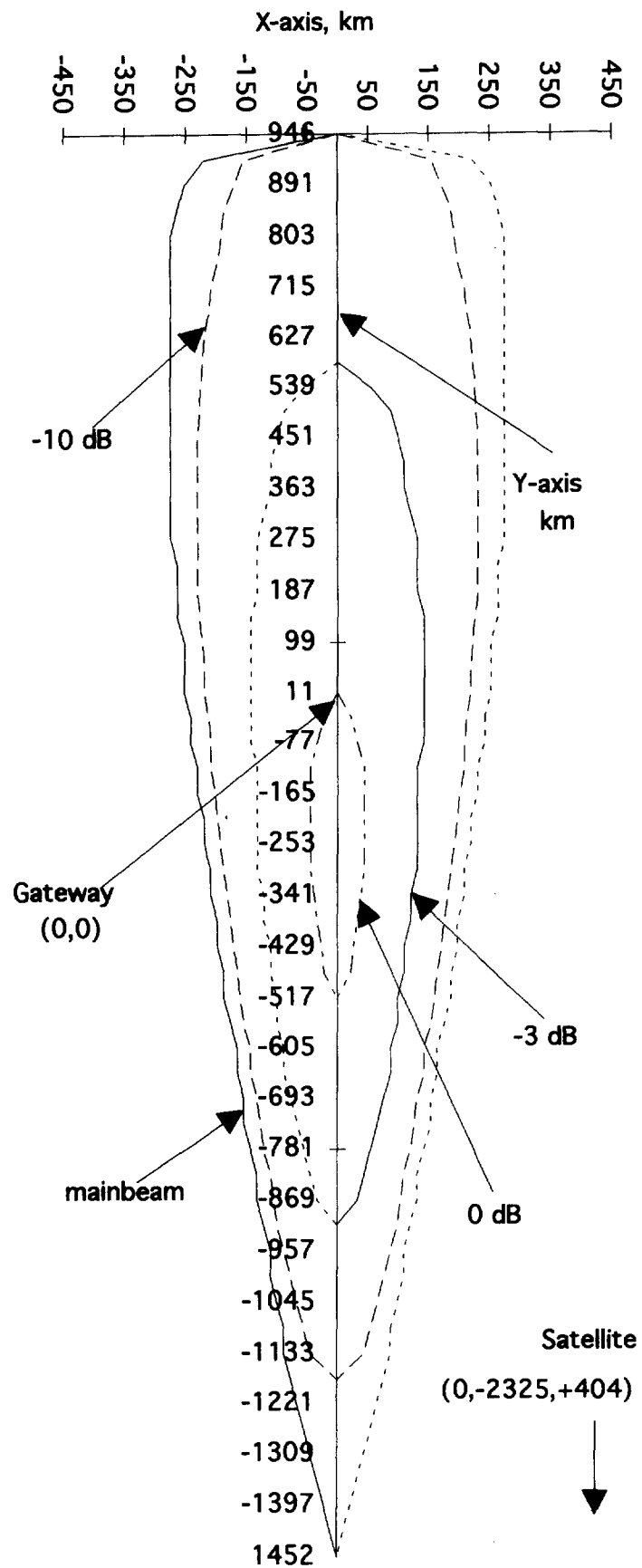2   This is not "coherent" addition of the hub emissions. This is a power addition.

Figure 1 Interference levels

Accordingly, when the number of occupied LMDS sites accumulates to 5.7% of the equivalent sites, the quality of the LEO system begins to fall below minimum design value. Stating this in other terms, if the stations are equally distributed in every 110 by 110 km area (about 4700 square miles) there could be a maximum of five stations before causing unacceptable interference. If the stations were grouped near the gateway site (or in the 0 dB area depicted in Figure 1) then the maximum number of stations is 170 with no other stations within the footprint. Because of rotation of the footprint, the exclusion area is about 1450 km in radius or 1800 Miles in diameter.

4.0 Interference Conclusions

The aggregate collection of LMDS hub transmitters would clearly contribute significant interference to the LEO feederlink 29 GHz uplink channel. Also, the aggregate power of the LMDS transmitters would be excessive for any reasonable probability of LMDS station installations.

G = Gateway
S = Satellite
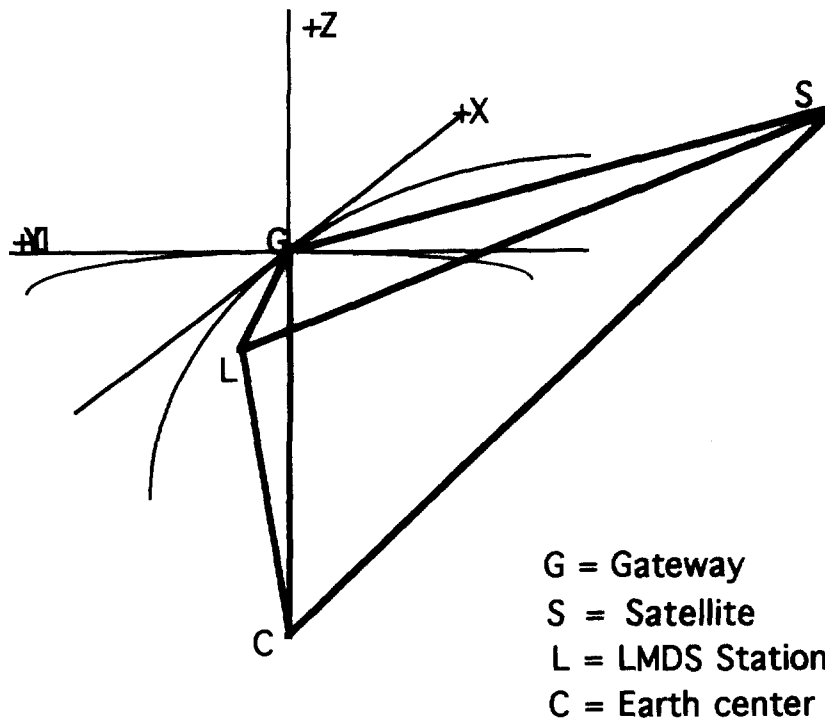L = LMDS Station
C = Earth center

Figure A1   Coordinate System

In this coordinate system the gateway is at (0,0,0); the satellite is at (0,-2325,+404); and the center of the earth is at (0,0,-6378).

A grid is then established on the XY plane. This produces a slightly distorted grid on the surface of the earth, however, the errors are small and in favor of the LMDS system. The grid lines are separated by 11 km. This dimension was determined by converting the stated LMDS service area to square kilometers and then taking the square root. The LMDS transmitters are located at the intersection of the grid and the respective Z coordinates are computed.

Given the X,Y,Z location of a LMDS station and the X,Y,Z location of the LEO satellite, the range, LMDS elevation angle, and the off bore site angle at the LEO satellite may be calculated.

The distance between the stations, the satellite and the center of the earth is calculated by using the three dimensional distance equation:

$$d = \text{square root of } ((X_1-X_2)^2 + (Y_1-Y_2)^2 + (Z_1-Z_2)^2)$$

From these distances, the relative range attenuation, the relative LMDS antenna gain, and the off boresite LEO antenna gain as related to the baseline LMDS station is calculated.

A.3   Relative Interference Coefficient

The relative interference coefficient for a given station is expressed as a multiple of the interference produced by a baseline station. The multiple, or relative interference equation, is the product of the square of the range ratio of the range of the LMDS station to the LEO satellite to the range of the gateway to the satellite, the relative LMDS antenna gain from baseline gain, and the relative gain of the satellite antenna towards the LMDS station.

A.3.1 Relative Range Attenuation

The relative range attenuation is the square of the ratio of the distance from the LMDS transmitter to the satellite (L-S) divided by the distance from the gateway to the satellite (G-S).

A.3.2 Relative LMDS Antenna Gain

The relative LMDS antenna gain is a function of the gain at the particular LDMS transmitter site. A discussion of the LMDS antenna is included in section 2.2 of the main report. From this discussion, the antenna is assumed to have a vertical profile equivalent to $\cos^2(1.8\varnothing)$. This yields half power gain at 25 degrees elevation and main beam cutoff at 50 degrees elevation. From Figure A1, the elevation angle is angle CGS minus 90°. Since the three sides of the triangle is known the elevation angle is readily calculated. The relative elevation antenna gain is then $\cos^2(1.8 *$ elevation angle) divided by $\cos^2(18°)$.

A.3.3 Relative LEO Satellite Antenna Gain

The relative LEO satellite antenna gain is the off boresite gain of the LEO satellite antenna referenced to the boresite gain. From Figure A1, the off boresite angle is angle GSL. Since the three sides of the triangle is known the off boresite angle is readily calculated. Given the angle the gain can be determined by using the gain function for horn antennas. The function used is the normalized function of 1/U times the first Bessel function of U, where U equals 38.6 Sin (ø). This U produces the beam shape of the design goal for the satellite antenna (i.e. 5° half power bandwidth)

A.4 Results

The above calculation is repeated for every LMDS station for X positions from -264 to +264 km and Y positions from -1452 to +946 km. All LMDS stations which are outside the main beam of the LEO satellite main beam are assigned a zero value. Likewise, all LMDS stations which have a less than zero degree elevation angle (optical line of site) are assigned a zero value. This process produces relative interference values for the LMDS stations in terms of equivalent baseline stations.

The mainbeam interference area, see Figure A2, includes over 7550 possible LDMS transmission sites. When the relative interference values for all of these LMDS stations are added, the LEO satellite receives interference energy equivalent to that produced by over 3000 baseline LMDS stations.

The mainbeam interference area is the outline of the interference contribution levels. This should not be confused with the foot print of the space antenna gain.
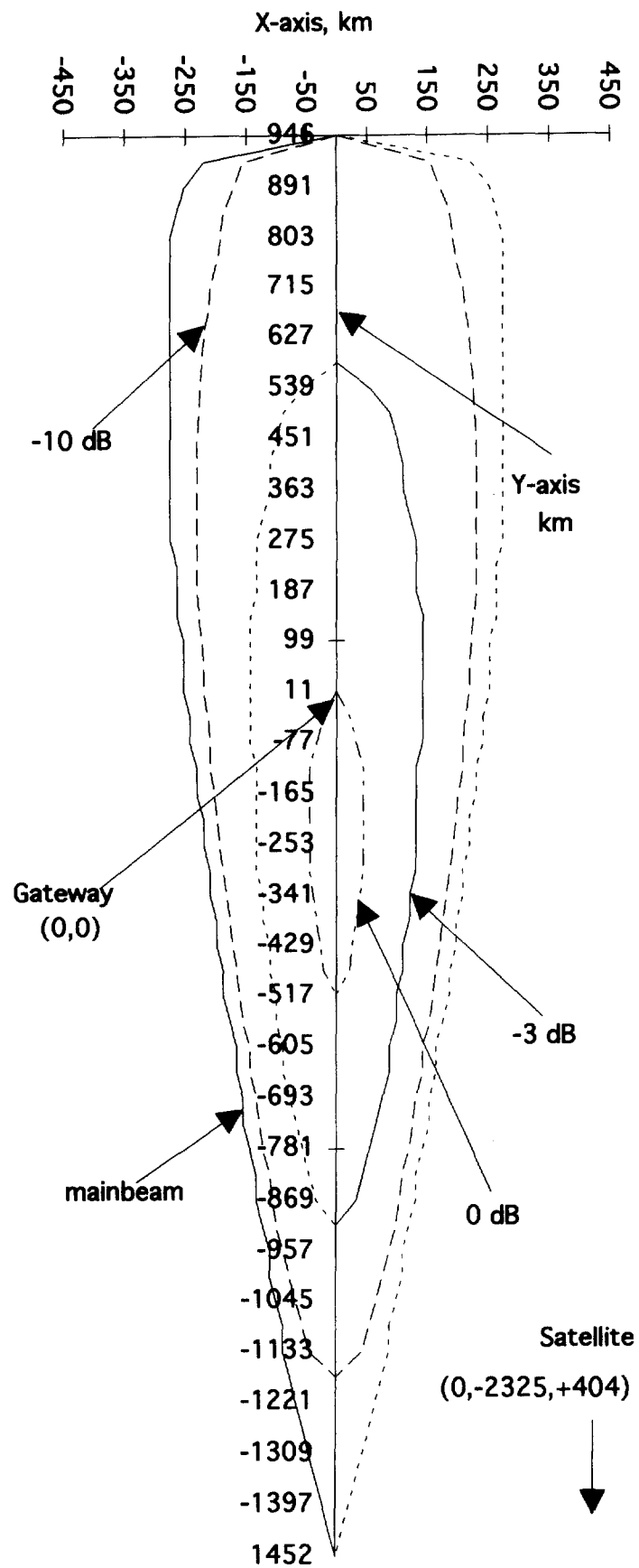
X-axis, km

-450 -350 -250 -150 -50 50 150 250 350 450

946

891

803

715

627

-10 dB

539

451

363

Y-axis
km

275

187

99

11

-77

Gateway
(0,0)

-165

-253

-341

-429

-517

-3 dB

-605

-693

mainbeam

-781

-869

0 dB

-957

-1045

Satellite
(0,-2325,+404)
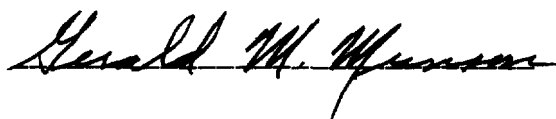
-1133

-1221

-1309

-1397

1452

Figure A2 Interference levels

ENGINEERING CERTIFICATE

I hereby certify that I am the technically qualified person responsible for the engineering information in this Technical Statement attached to the "SUPPLEMENTAL COMMENTS OF MOTOROLA SATELLITE COMMUNICATIONS, INC.", that I am familiar with Part 25 of the Commissions Rules, that I have either prepared or reviewed the engineering information submitted in this Petition, and, that it is complete and accurate to the best of my knowledge.

Gerald M. Munson
Spectrum Utilization Manager
Motorola Satellite Communications
Date: November 20, 1993

CERTIFICATE OF SERVICE

I, Philip L. Malet, hereby certify that the foregoing Motion and Supplemental Comments of Motorola Satellite Communications, Inc. were served by first-class mail, postage prepaid, this 22nd day of November, 1993 on the following persons:

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